भारत सरकार
नागर विमानन महावनदेशालय
Government of India
Directorate General of Civil Aviation

ANSS Advisory Circular AC 1 of 2023
Ref. DGCA-21040/1/2023-ANS
24. 11.2023

Sub: GNSS INTERFERENCE IN AIRSPACE

1. Introduction

1.1 A vast range of applications in civil aviation use GNSS for timing, position and navigation, both in aircraft and in space-based or ground-based systems.

1.2 GNSS Signals, being weak, are susceptible to interference. The interference which could be intentional or unintentional has potential to affect the services which require reliable GNSS signals.

1.3 With increased reliance and dependency on GNSS, GNSS interference including jamming and spoofing has become a real threat in airspace, and as such, active measures are required by all concerned to effectively deal with it.

2. Purpose

2.1 The purpose of this circular is:

(a) to increase awareness among aviation personnel about potential threats of GNSS Interference,
(b) to establish roles and responsibilities of different stakeholders in monitoring and mitigating threats,
(c) to establish an unambiguous channel for reporting GNSS Interference, and
(d) to establish a threat monitoring and analysis network.

3. Applicability

3.1 This circular is applicable to all Aircraft Operators and Air Navigation Service Provider (ANSP) for information, guidance and compliance.

4. Terms

4.1 Global Navigation Satellite System (GNSS)

A worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers and system integrity monitoring, augmented as necessary to support the required navigation performance for the intended operation. At present, GNSS includes satellite constellations of USA's Global Positioning System (GPS), Russia's GLONASS, Europe's Galileo and China's BeiDou.

4.2 GNSS Jamming

Intentional transmission of high-power signals creating interference (noise) with GNSS signals leading to loss of signal integrity at receiver, making GNSS unusable.

4.3 GNSS Spoofing or Smart Jamming

Intentional transmission of false GNSS−like signals that may be acquired and tracked in combination with or instead of the intended signals by receivers causing false and potentially confusing, or hazardously misleading, position, navigation, and/or date/time information in addition to loss of GNSS use.

5. GNSS Interference and affected areas

5.1 GNSS enables PBN and provides navigation guidance for all phases of flight, from en-route through to precision approach. By providing position information, GNSS enables ADS-B, ADS-C, moving map displays, multilateration, terrain awareness and warning systems (TAWS) and synthetic vision systems. Emergency locator transmitters (ELTs) also use GNSS position data. GNSS also supports a wide variety of precision timing applications.

5.2 GNSS signals are vulnerable to intentional and unintentional sources of interference and to certain ionosphere effects.

5.3 Unintentional interference could be due to variety of sources like in-band and out-of-band emitters, including mobile and fixed VHF communications, harmonics of television stations, certain radars, mobile satellite communication, microwave links, ionosphere effects, solar activity, multi-path error, GPS repeaters and even some systems on-board aircraft. However, these are usually localized and intermittent in impact.

5.4 Intentional interference due to jamming or spoofing attack could lead to hazardously misleading information which could affect the flight safety adversely. The

impact could be temporary with recovery on leaving the affected areas, or permanent with non-recoverable failure.

5.5 GNSS Interference cases have been observed with increased frequency in geographical areas surrounding conflict zones, southern and eastern Mediterranean and Black sea, Baltic Sea and Arctic area, especially in Istanbul and Ankara FIR in Turkey, Baghdad FIR, Tehran FIR, Tel Aviv FIR, Cairo FIR, Amman FIR among others in Mid-East region, Samara FIR, Moscow FIR and Minsk FIR.

5.6 The areas mentioned above in Para 5.5 are not exhaustive and subject to revision as new information becomes available.

6. Possible Impact of GNSS Interference

While there are no specific flight crew alerts for GNSS Interference, it is understood that both jamming and spoofing affect some or all of the applications that use GNSS input in aircraft. At present, it is difficult to distinguish one from the other conclusively based on impact. Further, impact is also dependent on aircraft avionics and system architecture. And as such, each operator should consult their OEM to understand possible impact on their aircraft fleet to remain aware of the vulnerabilities.

Some common list of examples are given below for reference:-

6.1 Impact on aircraft

Loss of or degradation in or misleading output in GNSS input based systems as illustrated in table below:-

GNSS Input based system	**Impacted systems/capability**
Positioning System	• Ground or wind speed on Navigation display • Map shift
Navigation System	• RNAV, RNP capability • SLS, GLS capability • INS/IRS
Timing Systems	• Time shift in clock • Fuel computation system • Flight management system
Surveillance System	• Automatic Dependent Surveillance (ADS) • Terrain Awareness/Ground Proximity Warning • Wind shear warning • Runway Alerting Systems

6.2 Impact on ground-based systems

6.2.1 Loss of surveillance capability (ADS-B, MLAT).

6.2.2 Degradation of ATM/CNS Systems.

6.3 Other Impact

6.3.1 Deviation of an aircraft from flight planned route may lead to separation minima infringement or airspace infringements.

6.3.2 Loss of GNSS signal could result in larger search areas for Emergency Locator transmitters (ELTs).

6.3.3 Loss of situational awareness could increase workload of flight crew and ATC.

7. Mitigation measures

Mitigation measures should consider first developing strategies for prevention, then reducing impact by building resilience and finally, reacting appropriately to GNSS service interruptions to ensure safety of flight operations.

GNSS interference may occur in any stage of flight (enroute, approach, etc.), and thus, it is important to consider associated risks and response time available to operational personnel concerned while developing the contingency procedures.

7.1 Airlines

7.1.1 Action by Aircraft Operators

(a) Understand the potential impact of GNSS Interference on their aircraft fleet.

(b) Conduct a safety risk assessment by assessing risks and hazards that may occur due to loss of on-board GNSS based systems. Refer Para 10.

(c) Coordinate with OEMs to obtain their recommendations in respect of GNSS Interference.

(d) Develop Contingency procedures to mitigate GNSS Interference on aircraft, including actions to be taken by flight crew experiencing the interference.

(e) Remain updated by studying various circulars issued by CAAs, ICAO and other international bodies, NOTAMs by ANSPs, case studies, etc.

(f) Timely brief flight crew and flight operations personnel of latest information on GNSS Interference, including:

(i) its potential impact
(ii) affected areas and air routes, and
(iii) reporting obligations.

(g) Include topic of GNSS Interference in recurrent training of flight crew and flight operational personnel.

(h) Ensure while flight planning, availability of critical nav aids on intended route of operation, and alternate conventional instrument approach procedures in case of an aerodrome in affected areas with only GNSS based approaches.

(i) Report the events of GNSS interference (actual or suspected). Refer Para 8.

(j) Analyse reports of GNSS interference in coordination with OEM and ANSP to determine root cause analysis.

7.1.2 Action by Pilots

(a) Understand possibility of GNSS Interference and its impact.

(b) Closely monitor aircraft position and cross-check the same using information from conventional navigation aids, cross-check GNSS time with non-GNSS time sources, and observe flight instruments for discrepancies or GNSS anomalies.

(c) Operators to insure that correct IRS alignment procedures as recommended by OEM are followed concisely before departure. The alignment procedure has to crosscheck by both operating crew.

(d) Actively monitor ATC frequency including distress frequency 121.5 MHz.

(e) Be prepared to revert to conventional navigation instruments and procedures.

(f) In case of suspected or actual GNSS Interference,

(i) notify ATC as soon as practicable and request assistance as required.
(ii) implement contingency procedures as appropriate.

(j) Report the event to appropriate authorities. Refer Para 8.

(a) Understand the impact of GNSS Interference on ATM/CNS Systems including SBAS (GAGAN), surveillance systems (ADS-B) and GNSS based timing systems.

(b) Conduct a safety risk assessment by assessing risks and hazards that may occur due to loss of SBAS (GAGAN), GNSS based surveillance or timing systems on aircraft operations in specific airspace.

(c) Develop contingency procedures to mitigate GNSS interference in airspace, including actions to be taken by air traffic controllers receiving reports of interference or experiencing loss of or unreliable GNSS-based surveillance system (ADS-B).

(d) Issue NOTAMs as appropriate to disseminate information about affected areas or air routes.

(e) Coordinate with military authorities on activities potentially hazardous to civil aircraft like use of GNSS jammers during military exercises and operations close to civil aerodrome or airspace, and notify airspace users using NOTAMs.

(f) Consider impact of GNSS interference during planning for rationalization of conventional navigation and surveillance infrastructure.

(g) Maintain essential conventional navigation aid infrastructure (VOR, DME, ILS) and procedures based on them, and GNSS impact-resilient surveillance infrastructure.

(h) Sensitize Air traffic controllers of GNSS Interference, and include the topic in their refresher trainings.

(i) Establish mechanism to collect and analyse reports of GNSS interference, and notify to airspace users and DGCA. Refer Para 9.

(j) Establish procedures to identify and locate the source of GNSS interference, if possible, and eliminate the same in cooperation with local regulatory and law enforcement authorities.

7.2.2 Action by Air Traffic Controllers

(a) Closely monitor aircraft traffic for unauthorized deviations from intended track or route, if in surveillance environment.

(b) Actively monitor distress frequency 121.5 MHz.

(c) In case of loss of or unreliable GNSS-based surveillance system like ADS-B, implement contingency procedures as appropriate.

(d) In case of suspected or actual GNSS Interference by flight crew,

(i) provide positioning and navigation assistance to affected aircraft.
(ii) cross-check with other aircraft in vicinity.
(iii) broadcast interference report to other aircraft, as necessary.
(iv) implement contingency procedures as appropriate.

(e) Report the event to appropriate authorities. Refer Para 8.

8. Reporting

8.1 Reporting Requirement

It is mandatory for all operators, flight crew, Air navigation service provider and air traffic controllers to report any event of actual or suspected GNSS Interference leading to a safety occurrence, in accordance with the Aircraft Rules 1937, Rule 29E and CAR Sec 5 Series C Part 1.

8.2 Reporting Format

(a) A reporting form for pilots is given in eAIP India ENR 4.3 Para 10.
(b) A general reporting format for all is also given in Appendix 1 to this circular.

8.3 Reporting Channel

All reports are to be sent via email to Director (Air Safety) and Director (AS & ANSS), DGCA HQ with a copy to GM CNS, GAGAN, AAI. The email addresses are given in Appendix 3.

9. Threat Monitoring and Analysis Network

9.1 ANSP should establish an internal mechanism in coordination with relevant stakeholders and subject matter experts of industry, academia, etc., for preventive as well as reactive threat monitoring, and analysis of all reports of GNSS Interference.

9.2 Relevant data should be maintained to obtain insight into emerging trends, threats, and geographical areas of concern.

9.3 Periodic updates should be shared with DGCA using the reporting channel given in Para 8.3 on bi-monthly basis, for further action as appropriate.

9.4 Any significant finding or outcome may be brought to immediate attention of DGCA and airspace users, as necessary.

10. Safety Risk Assessment

10.1 Airlines should assess risks and operational limitations that may occur due to loss of on-board GNSS based systems.

10.2 ANS providers should complete a risk assessment by determining the residual likelihood of service outages and the impact of an outage on aircraft operations in specific airspace. It should also consider the type of airspace, traffic levels and the availability of independent surveillance and communications services.

10.3 All operators should formulate SOP, conduct the risk assessment and submit the same to FSD dte, DGCA HQ.

10.4 ANSP should formulate SOP, conduct the risk assessment and submit the same to AS & ANSS dte, DGCA HQ.

10.5 A sample risk assessment table is provided in Appendix 2 to this circular.

Vikram Dev Dutt
Director General of Civil Aviation

Appendix 1

Reporting Format GNSS Interference Occurrence

Originator of Report	
Report Filed by	[] Aircraft Operator [] Flight Crew [] Air Navigation Service Provider [] Air traffic Controller [] Any other
Date and Time of Report (dd/mm/yyyy) and UTC	
Aircraft Operator Details	
Name	
Email address	
Flight Details	
Call sign of Aircraft (Flight No.)	
Flight Sector	
Airway/ Route of occurrence	
FIR code	
Flight Level or Altitude during event	
Phase of flight	
Aircraft Type	
Aircraft Registration	
ATS Details	
Location of ATS Station (Location identifier)	
Surveillance Systems details	
Affected airspace Details	
Event Details	
Affected GNSS Element	[] GPS [] GLONASS [] GAGAN [] Any other. Pls Specify:
Coordinates of the first point of occurrence / Time (UTC):	UTC: Lat: Long:

Coordinates of the last point of occurrence / Time (UTC):	UTC: Lat: Long:
Duration of Observed Interference/outage:	
Impact Details	
List of impacted systems:	
Observation of a "time shift" on clock (details of shift and recovery, if any)	
Observation of a "map shift" on navigation display (details of shift and recovery, if any)	
Enhanced ground proximity warning alerts:	
Degraded EPU (Estimated Position Uncertainity)/ Estimated Position Error	
Loss of automatic dependent surveillance (ADS) reporting capabilities (ADS-B out, ADSB-in, ADS-C) (details)	
Loss of GNSS-based landing capability.	
Large position errors (details):	
Loss of integrity (RAIM warning/alert):	
Complete outage (Both receivers):	
Loss of GPS1 or Loss of GPS 2	
Loss of satellites in view/details:	
Lateral indicated performance level change	From: To:
Vertical indicated performance level change	From: To:
Indicated Dilution of Precision changed	From: To:
information on PRN of affected satellites (if applicable)	
Low Signal-to-Noise (Density) ratio:	
Degraded PBN capability	
Switching to an alternate navigation mode (such as IRS updating or DME/DME)	
Any other observed impact:	
Automatic GNSS Systems Recovery (y/n)	
Other	
Any other relevant details:	

Note: *All available details should be provided. Separate sheet may be attached for additional information/pictures, etc, if any.*

Appendix 2

Sample Risk Assessment Format

The following tables have been adopted from ICAO Guidance Material related to GNSS Vulnerability for MID region (Doc Ref. RSA-14)

1. Sample Risk Assessment Table:

It could be used to identify and capture the threats, select the risk rating based on the risk matrix above considering the existing controls. In addition, recommended actions could be selected to minimize the risk.

Here, L denotes Likelihood, C denotes Consequence, and R denotes Risk.

Threat	Initial Risk			Existing controls	Accept/Reduce	Recommended controls	Residual Risk		
	L	C	R				L	C	R

2. Likelihood (L) of an identified risk occurring:

Event is expected to occur	
1	More frequently than hourly
2	Between hourly and daily
3	Between daily and yearly
4	Between yearly and 5 yearly
5	Between 5 and 50 years
6	Less frequently than once every 50 years

3. Consequence (C)/impact of risk occurring:

Category	Effect on Aircrew and Passengers	Overall ATM System effect

Catastrophic 1	Multiple fatalities due to collision with other aircraft, obstacles or terrain	Sustained inability to provide any service.
Major 2	Large reduction in safety margin; serious or fatal injury to small number; serious physical distress toair crew.	Inability to provide any degree of service (includingcontingency measures) within one or more airspace sectors for a significant time.
Moderate 3	Significant reduction in safety margin.	The ability to provide a service is severely compromised within one or more airspace sectors without warning for a significant time.
Minor 4	Slight reduction in safety margin.	The ability to provide a service is impaired within one or more airspace sectors without warning for a significant time
Negligible 5	Potential for some inconvenience.	No effect on the ability to provide a service in the short term, but the situation needs to be monitored and reviewed for the need to apply some form of contingency measures if the condition prevails.

4. Risk Assessment Matrix

The following matrix provides for an overall risk ranking based on L and C criteria:

Likelihood Criteria		**Consequence Criteria**				
Event expected to occur:		**Catastrophic 1**	**Major 2**	**Moderate 3**	**Minor 4**	**Negligible 5**
1	**More frequently than hourly**	**A**	**A**	**A**	**A**	**C**
2	**Between hourly and daily**	**A**	**A**	**A**	**B**	**D**
3	**Between daily and yearly**	**A**	**A**	**B**	**C**	**D**
4	**Between yearly and 5 yearly**	**A**	**B**	**C**	**C**	**D**
5	**Between 5 and 50 years**	**A**	**B**	**C**	**D**	**D**
6	**Less frequently than once every 50 years**	**B**	**C**	**D**	**D**	**D**

5. Risk (R) Tolerability:

Based on the risk assessment matrix, risks are categories from ‘A’ to ‘D’, with ‘A’ being unacceptable and ‘D’ being acceptable**.**

Risk Index Range	Description	Recommended Action
A	Unacceptable	Stop or cut back operation promptly if necessary. Perform priority/immediate risk mitigation to ensure that additional orenhanced preventive controls are put in place to bring down the risk index to the moderate or low range
B	High Risk	Urgent action. Perform priority/immediate risk mitigation to ensure that additional or enhanced preventive controls are putin place to bring down the risk index to the moderate or low range
C	Moderate Risk	Countermeasures actions to mitigate these risks should beimplemented.
D	Low Risk	Acceptable as is. No further risk mitigation required

ICAO Doc 9849 Appendix F Para 5.3.2 provides additional guidance on risk assessment.

Further guidance on risk assessment may be obtained from FSD dte, DGCA HQ.

Appendix 3

Email Addresses of Reporting Channel

S.N.	Designation	Email Address
1	Director of Air Safety, DGCA	sanit.dgca@nic.in
2	Director of Operations, AS & ANSS, DGCA	jamwal.dgca@nic.in
3	General Manager (CNS), GAGAN, AAI	gmcnsgnss@aai.aero